Option —02
Ohms Converter

602-1. INTRODUCTION

602-2. Installation of the Ohms Converter provides precision resistance measurement capability ranging from 100 μΩ to 262 MΩ. Both two-terminal and four-terminal measurements may be made.

602-3. SPECIFICATIONS

602-4. Table 602-1 lists the specifications of the Ohms Converter.

602-5. INSTALLATION

602-6. Refer to Section 4 of this manual under Module Installation and Removal for instructions on installing and removing modules. The interconnect diagram in Section 8 contains a table listing permissible and preferred slots.

602-7. OPERATING NOTES

602-8. Operation of the front panel controls with the Ohms Converter Option installed is the same as described in Section 2 of this manual. Eight ranges are available for resistance measurements: 10, 100, 1K, 10K, 100K, 1M, 10M, and 100M. Ranges may be either manually or automatically selected. Four-wire measurements may be made up through the 100K range. In the 1M, 10M, and 100M ranges only two-wire measurements may be made, as lead resistance will not affect accuracy. However, the four-wire connections may still be used if desired. Sense HI to Source HI and Sense LO to Source LO connections must be made either with the shorting links provided (two-wire mode) or at the resistance to be measured (four-wire mode). Figure 602-1 shows possible connections for both the two-wire and four-wire modes.

Table 602-1. Ohms Converter Specifications

ACCURACY (Refer to the specifications table in section 1 for required environmental conditions)						
Range	NORMAL RESOLUTION Accuracy ± (% of Input + No. of Digits)			HIGH RESOLUTION Accuracy ± (% of Input + No. of Digits		
	24 Hours	90 Days	1 Year	24 Hours	90 Days	1 Year
10Ω	0.003 + 20	0.005 + 20	0.01 + 20	—	—	—
100Ω	0.002 + 2	0.003 + 2	0.006 + 2	0.002 + 14	0.003 + 14	0.006 + 14
1 kΩ	0.002 + 1	0.003 + 1	0.006 + 1	0.002 + 8	0.003 + 8	0.006 + 8
10kΩ	0.002 + 1	0.003 + 1	0.006 + 1	0.002 + 8	0.003 + 8	0.006 + 8
100 kΩ	0.002 + 1	0.003 + 1	0.006 + 1	0.002 + 8	0.003 + 8	0.006 + 8
1 MΩ	0.002 + 1	0.003 + 1	0.006 + 1	0.002 + 8	0.003 + 8	0.006 + 8
10 MΩ	0.01 + 1	0.02 + 1	0.04 + 1	0.01 + 8	0. 02 + 8	0.004 + 8
100 MΩ	0.03 + 1	0.05 + 1	0.1 + 1	0.03 + 8	0.05 + 8	0.1 + 8

Table 602-1. Ohms Converter Specifications (Continued)

OPERATING CHARACTERISTICS

Range	Full Scale	Current Through Unknown	Normal Resolution		High Resolution	
			Resolution	Temperature Coefficient* ± (ppm/rdg + No. of Digits)/°C	Resolution	Temperature Coefficient* ± (ppm/rdg + No. of Digits)/°C
10Ω	31.25Ω	10 mA	100 uΩ	8 + 1.5	–	–
100Ω	250Ω	10 mA	1 mΩ	7 + 0.2	100 uΩ	7 + 2
1 kΩ	2 kΩ	1.25 mA	10 mΩ	7 + 0.2	1 mΩ	7 + 2
10 kΩ	32 kΩ	78 uA	100 mΩ	7 + 0.2	10 mΩ	7 + 2
100 kΩ	256 kΩ	9.8 uA	1Ω	7 + 0.2	100 mΩ	7 + 2
1 MΩ	4.096 MΩ	4.9 uA	10Ω	7 + 0.2	1Ω	7 + 2
10 MΩ	32.768 MΩ	0.61 uA	100Ω	30 + 0.2	10Ω	30 + 2
100 MΩ	262.144 MΩ	76 nA	1 kΩ	50 + 0.2	100Ω	50 + 2

*0°C to 18°C and 28°C to 50°C

MAXIMUM LEAD RESISTANCE

Mode	Leads	Range	Maximum Lead Resistance
4-wire	Source	10 – 100Ω	10Ω
4-wire	Source	1 kΩ	100Ω
4-wire	Source	10 kΩ – 100 MΩ	1 kΩ
4-wire	Source	All	1 kΩ
2-wire	Source	All	Less than 0.001% of range unless offset

OPEN CIRCUIT VOLTAGE

Range	Voltage	Configuration
10Ω to 100 kΩ	7 volts max	4 Terminal
1 MΩ to 100 MΩ	25 volts max	2 Terminal

OVERLOAD

± 400V dc to 60 Hz, or 560 volts peak ac above 60 Hz maximum continuous on any range with no damage.

SETTLING TIME – (To Rated Accuracy)

80 ms, Fast Filter
800 ms, Slow Filter

DIGITIZING TIME

Mode of Operation	Filter	60 Hz		50 Hz	
		Approx. Rdg. Rate	Digitizing Time	Approx. Rdg. Rate	Digitizing Time
Bench	Fast	4 rdg/s	250 ms	3-1/3 rdg/s	300 ms
	Fast	1-1/2 rdg/s	700 ms	1-1/4 rdg/s	800 ms
	Slow	1-1/4 rdg/s	800 ms	1 rdg	1000 ms
	Slow	5/6 rdg	1200 ms	3/4 rdg	1450 ms
Remote	Fast	4 samples/rdg	145 ms	4 samples/rdg	175 ms
	Slow	4 samples/rdg	700 ms	4 samples/rdg	840 ms
(Subtract for fast Ohms)	Fast	–	110 ms	–	–
	Slow	–	560 ms	–	–

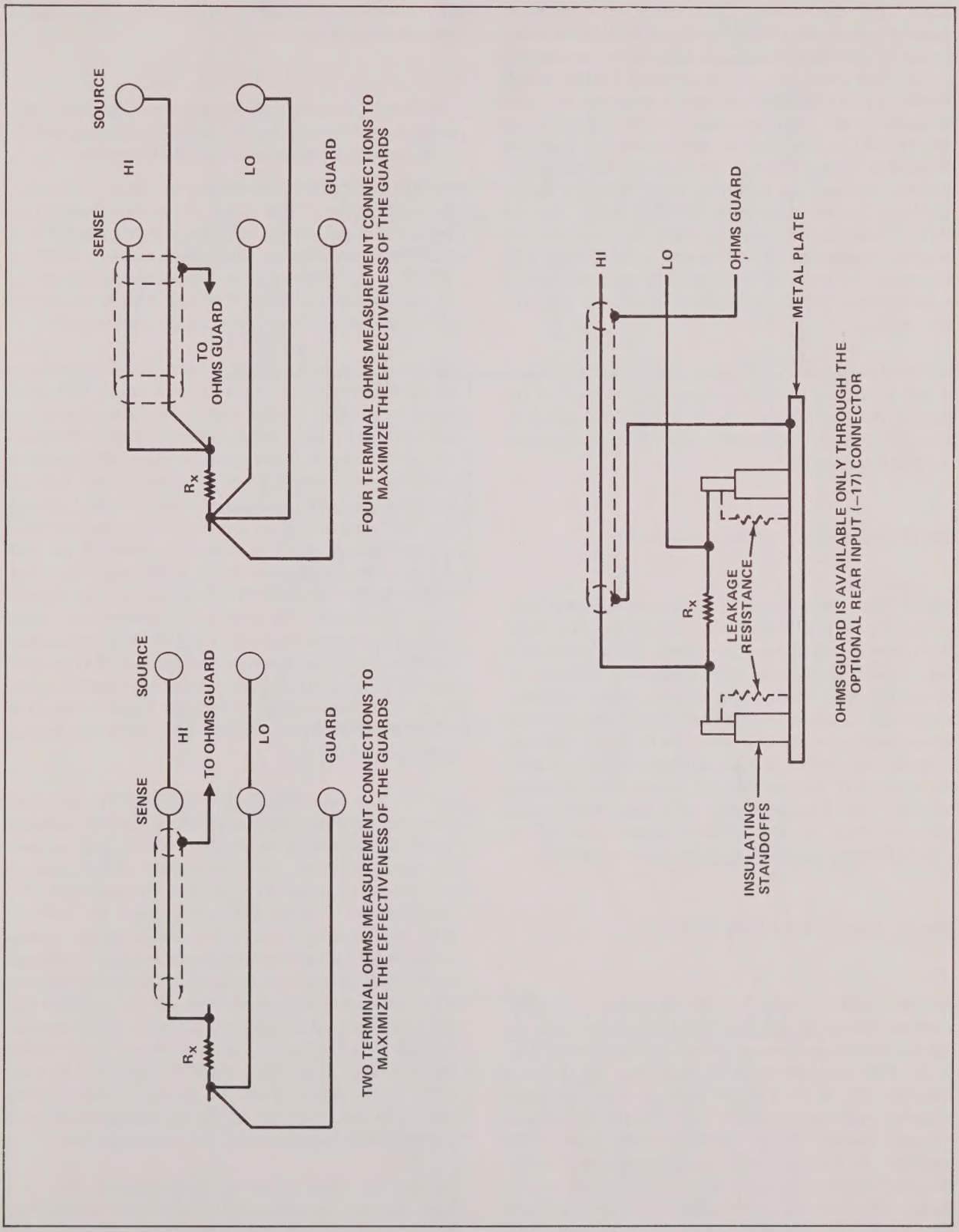


Figure 602-1. Ohms Measurement Connections And Guarding

602-9. For the two-wire ohms mode, the instrument should be zeroed with a good quality short between Sense-Source HI and Sense-Source LO. Select either autoranging or the 10Ω range manually. Depress the STORE switch. Depress the V DC/Ω ZERO switch. All ranges are now automatically zeroed. Ohms zero cannot be recalled. Depressing the RECALL switch while in Ohms results in a display of ERROR 0, then a return to the program. To compensate for lead resistance use the Offset mode. Short the ends of the leads together. Depress the STORE switch, then the OFFSET switch. This enters the lead resistance value into memory. Depress the OFFSET switch again (OFFSET LED illuminated) to enter the Offset mode in which the value of lead resistance will automatically be subtracted from further readings.

602-10. In the four-wire ohms mode, the instrument should be zeroed by placing a good quality short at the ends of the leads. Depress the V DC/Ω ZERO switch to enter the zero value, which will automatically be subtracted from further readings.

602-11. Guarding

602-12. The ohms guard connection is available only through the optional Rear Input Connection (−17). Figure 602-1 shows optimal use of the guard. Basically the ohms guard is used to minimize leakage resistance between the HI and LO leads which would appear as shunt resistance across high R_X values. In some high-resistance measurement set-ups, leakage resistance in or on the surface of insulating materials may provide enough shunt resistance to degrade the accuracy of the measurement. Figure 602-1 illustrates one such case. Connecting the ohms guard to the metal plate on which the standoffs are mounted reduces the effect of leakage resistance through or on the standoffs.

602-13. THEORY OF OPERATION

602-14. The function of the Ohms Converter is to produce a current through an unknown resistance such that the voltage across the unknown is proportional to the value of resistance. This is accomplished by configuring the unknown resistance, R_X, as the feedback element of an operational amplifier. A reference voltage, V_{REF}, is applied through a reference resistor, R_{REF}, to the summing node of the amplifier. By definition of an ideal operational amplifier, the current through R_X is the same current flowing through R_{REF} (the summing node represents a virtual ground). Figure 602-2 is a simplified schematic of the Ohms Converter and contains an illustration of the derivation of the formula for R_X. The current flowing through R_{REF} equals $(V_1 - V_2)/R_{REF}$. Using the expression for current to obtain the value of R_X:

$$R_X = R_{REF} \left(\frac{V_O}{V_1 - V_2}\right).$$

The Ohms Converter multiplexes the voltages which, after being routed through the DC Signal Conditioner and the Filter module, are measured by the A/D Converter.

602-15. The current reference for the Ohms Converter is derived from the −7V reference (RT4) from the A/D Converter. U4 is an inverting amplifier with two possible feedback paths to produce either approximately +2.3V or +18.5V as V_1. U4 drives Q8 with Q8 serving as a larger current source than is available from U4. R41, R45, and R56 are the reference resistors, each having an adjustment.

602-16. R_X is the feedback element for the operational amplifier composed of Q9 and U5. U5 drives Q37 which serves as a higher current source. This arrangement also allows a larger output voltage swing. Note that Q9 and U5 are configured as an inverter, yet the output of U5 is a positive voltage. Q37 draws its emitter current through R48 and R49 from the −30V supply with CR18 and CR13 ensuring that Q37 need not be in a state of saturation. SOURCE voltages out are negative voltages at SOURCE LO with respect to circuit common. In the 100M range, the voltage applied to R41 is divided by 8. However, the unattenuated V_{REF} is measured. The factor of 8 is preserved by assigning R_{REF} the value of 8 x R41 (32.768 MΩ) in the equation. As the Ohms Converter downranges, R41 remains enabled so lower R_{REF} values are actually parallel combitions. V_2 is not measured in the three highest ranges (1M, 10M, 100M) since lead resistance will not be large enough to affect accuracy.

602-17. Extensive overvoltage protection has been provided for the Ohms Converter. Refer to the full schematic. Voltages appearing on the SENSE or SOURCE HI terminals in excess of +28V or −3V (with respect to circuit common) are clamped to ground by Q14, CR7, Q10, and Q39. U5 is configured as a voltage comparator biased by CR19 and R14. The clamping action of Q14 or Q10 causes a voltage on the input Lo line which triggers comparator U5 through Q11 or Q15. In either case the output at U5 pin 7 toggles to its maximum positive level, clocking U3 while placing a high on the ID3 line. This opens relay K1 and removes the input voltages from the module. The high from U5 also inhibits the ACK logic so an Error 4 will be displayed. CR13 and CR14 at the output of Q9, U5 are high voltage blocking diodes. E1 is a spark gap preventing voltages in excess of 400V between the guard shield and circuit common.

602-18. The Ohms Converter is addressed by IC1, 2, 3 high, and must be addressed for each sample voltage. Samples are multiplexed out at the rate of one every four msec. This requires the fastest response time in the DC Signal Conditioner of any measurement mode.

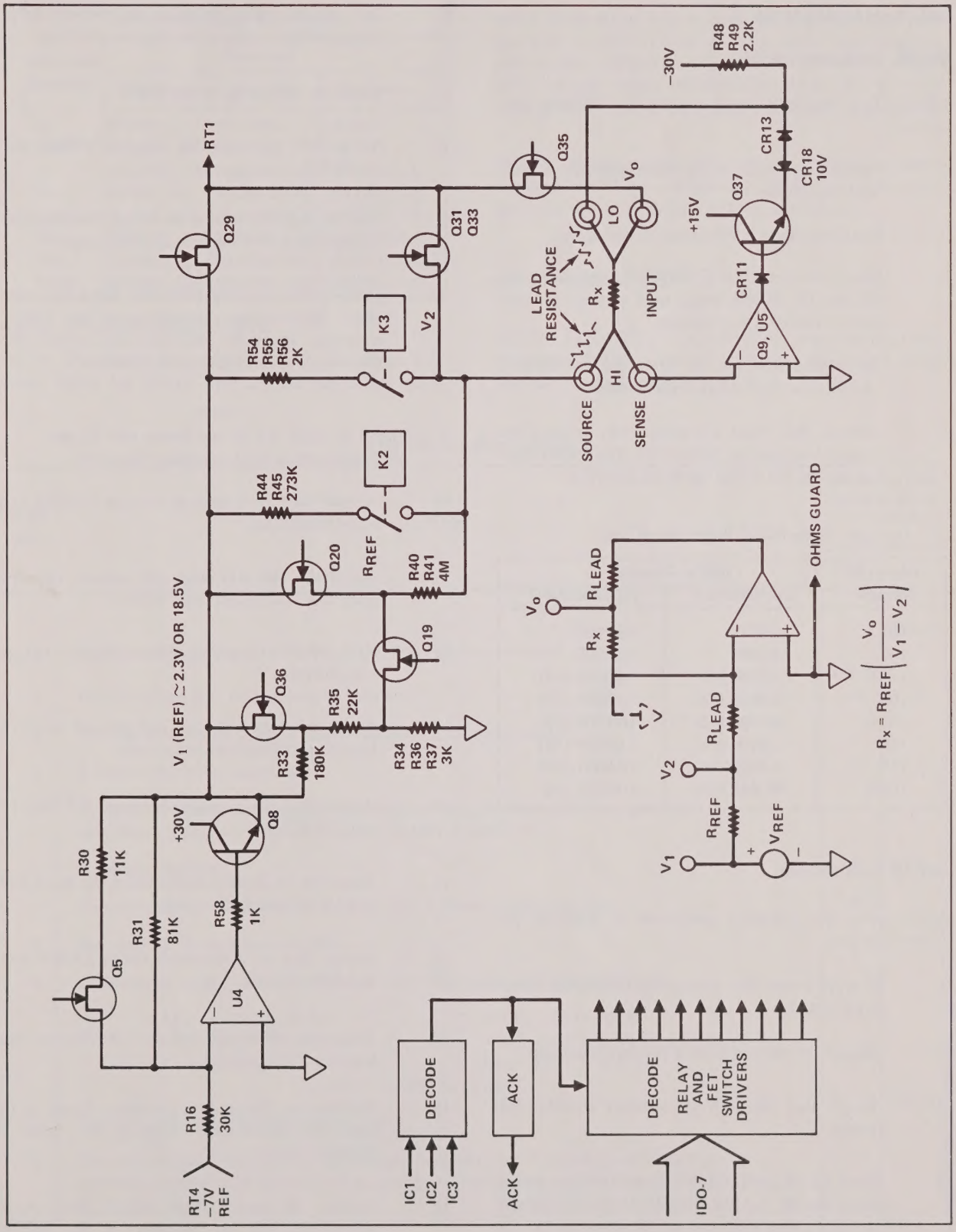


Figure 602-2. Ohms Converter

602-19. MAINTENANCE

602-20. Performance Test

602-21. Test the Ohms function using the following procedure:

1. Connect test leads to the instrument in the four-wire configuration.

2. Select the Ohms function and Autoranging.

3. Short the HI and LO Ω SOURCE leads, short the HI and LO SENSE leads; then connect the two pairs of shorted leads together.

4. Zero the instrument by depressing the STORE switch, then the V DC/Ω ZERO switch.

5. Remove the shorts and sequentially connect the standard resistors in Table 602-2. The 8500A readings should fall within the limits specified.

Table 602-2. Performance Test

Standard Resistor	8500A Reading	
	Low (exponent)	High (exponent)
10	9.9975	10.0025
100	99.995	100.005
1K	.99996 (+3)	1.00004 (+3)
10K	9.9996 (+3)	10.0004 (+3)
100K	99.996 (+3)	100.004 (+3)
1M	.99996 (+6)	1.00004 (+6)
10M	9.9979 (+6)	10.0021 (+6)
100M	99.949 (+6)	100.051 (+6)

602-22. Calibration

602-23. Use the following procedure to calibrate the Ohms Converter:

1. Remove power and remove the Calibration Memory if installed.

2. Reapply power and allow a two hour warm-up.

3. Ensure that the dc Volts accuracy is within tolerance.

4. Short the HI and LO AMPS/Ω SOURCE terminals, short the HI, LO and GUARD VOLTS/Ω SENSE terminals, then short the two HI terminals. Use the terminal shorting links provided with the instrument and/or equivalents.

5. Use manual range selection to prevent range changes while testing at the range extremities.

6. Select the 10Ω range on the DMM.

7. Adjust R24 for a reading between -0.0003 and +0.0003.

8. Step through the other seven ranges, checking that the reading is 0 ± 1 digit on all seven ranges.

9. Remove the shorting links and make four-wire ohms measurement connections to the INPUT terminals. Select the 1MΩ range and connect the input leads to a 4 MΩ standard resistor.

NOTE

Refer to Table 4-1 of the Instruction Manual for specifications on the Standard Resistors.

10. Adjust R40 for a reading between 3.99998 (+6) and 4.00002 (+6).

11. Select the 100 MΩ range and connect the input leads to a 100 MΩ standard resistor.

12. Adjust R37 for a reading between 99.995 (+6) and 100.005 (+6).

13. Select the 100 kΩ range and connect the input leads to a 250 kΩ standard resistor.

14. Adjust R44 for a reading between 249.998 (+3) and 250.002 (+3).

15. Select the 1 kΩ range and connect the input leads to a 1.9 kΩ standard resistor.

16. Adjust R54 for a reading between 1.89998 (+3) and 1.90002 (+3).

17. Select the 10Ω range and short the four-terminal leads for a zero input.

18. Perform the Ohms Zero procedure found in the operating instructions, ensuring the result is 0.0000 ± 1 digit.

19. Perform the tests in Table 602-3. There are no adjustments for the readings, if any reading exceeds the listed tolerance the module is not acceptable.

Table 602-3. Calibration Tests

Resistance Standard	Readings		
	Minimum	Nominal	Maximum
10	9.9989	10.0000	10.0011
100	99.997	100.000	100.003
1k	0.99997 (+3)	1.00000 (+3)	1.00003 (+3)
10k	9.9997 (+3)	10.0000 (+3)	10.0003 (+3)
100k	99.997 (+3)	100.000 (+3)	100.003 (+3)
1M	0.99997 (+6)	1.00000 (+6)	1.00003 (+6)
10M	9.9989 (+6)	10.0000 (+6)	10.0011 (+6)
100M	99.969 (+6)	100.000 (+6)	100.031 (+6)

602-24. TROUBLESHOOTING

602-25. Troubleshooting procedures for the Ohms Converter follow the format used for the mainframe instrument. Table 602-4, Failure Isolation, assures that the problem is in the Ohms Converter. Table 602-5 lists symptoms and possible failures in the order of probability. Figure 602-3 shows timing relationships, while Tables 602-6 through 602-8 give additional troubleshooting information.

602-26. Always remove power before removing or installing modules. RT1 is available only in the front four option slots and not in the Isolator or Interconnect slot.

602-27. PARTS LIST

602-28. Table 602-9 is a parts breakdown for the Ohms Converter. Refer to Section 5 of this manual for ordering and use code information.

Table 602-4. Failure Isolation

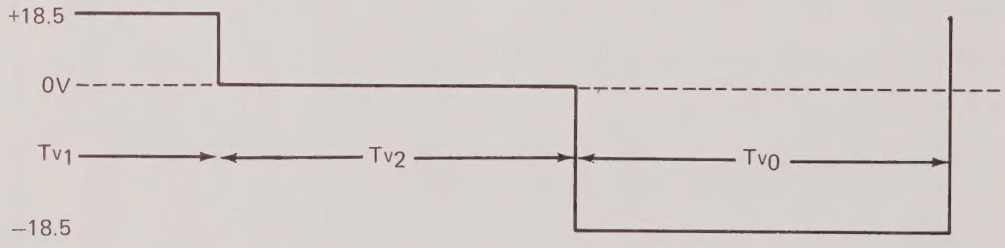
STEP NO.	ACTION	Go to the step number given for correct response	
		YES	NO
1	Perform DC Volts test (Section 4). Is DC Volts within tolerance?	2	Section 4
2	Perform Ohms test. Is Ohms within tolerance?	Section 4	3
3	Remove all optional modules except Isolator and Ohms converter.		
4	Is Ohms now within tolerance?	5	6
5	An optional module is affecting Ohms. Replace one at a time until Ohms goes bad. Last one in is faulty – go to appropriate portion of Section 6.		
6	Is Isolator installed?	7	9
7	Remove Isolator. Insert Jumper/Monitor pcb. Is Ohms within tolerance:	8	9
8	Bad Isolator. Go to Subsection 608.		
9	Check power supply voltages as follows. Test DMM LO on AR (analog return). VA1 = +14.25 to 15.75V VA2 = –14.25 to –15.75V VA3 = +29 to 32V VA4 = –29 to –32V Vcc = –15V, Vss = –20V } Difference = 4.9 to 5.2 RT4 = –6.993 to –7.007		
10	Are the supply voltages within tolerance?	11	Section 4
11	The problem is probably in the Ohms board. However, the DC Signal Conditioner may contribute errors if the slew rates of the amplifiers are not fast enough. Go to Table 602-5.		

Table 602-5. Symptom Analysis

SYMPTOM	POSSIBLE FAILURE
No Ohms Readings (V_0)	U5, Q9, Q35, Digital Logic
(V_1)	U4, Q8, Q29 Digital Logic & Drivers
Ohms Zero Drift	U5, Q9
10K – 100K Ranges Bad	Q32, Q33, Digital
10 – 100 – 1K Ranges Bad	Q30, Q31, Digital
10M Full Scale Low	Q20, Q22
No ACK	U5, Q14, Q11, Q38
All Ranges Out of Tolerance	Q37, U5
100M Noisy, 30M High	Q10, K3 Shorted
1K, 100K, 10M, 100M Ranges Bad	Q5, Q4
100M Range Bad	Q20, Q22, Q19 Leaky
Display Error 4 with no voltage at input	Q14
Noisy at 30M or Full Scale	CR15, CR17, CR4, CR8
Full Scale 1M, 10M, 100M Ranges Out of Tolerance	CR18
DC SIGNAL CONDITIONER	
Slew Rates Bad	Q37, Q38, Q19, U3, U5, U6

Note: If Q9, Q19, U5, R19, R20, R21, R23, R25, or R26 are replaced it is necessary to return the module to the factory (Attn: Parts) for temperature compensation.

Voltages shown are at RT6, (DC Signal Conditioner Output).



Vo is proportional to Rx, Vo for full scale Rx is shown.

Sample Rate	Filter	Tv_1	Tv_2 *	Tv_0
Fast	No	30ms	30ms	200 ms
Fast	Yes	30ms	30ms	650ms
Slow	No	30ms	30ms	600ms
Slow	Yes	30ms	30ms	1060ms

These are approximate times.

*Except Tv_2 for ranges 1M, 10M, 100M is zero. No V_2 is measured for these ranges.

The first reading after a range change or overrange is modified with longer V_1 and V_2 periods.

Figure 602-3. Timing

Table 602-6. Voltage Measurements

Range	Full Scale	V* TP2	R ref	I ref* (Source HI)	V_0* (Range Value)	V_1* (TP2)	V_2 (Offset)
10	31.25	+18.5V	2K	9.3ma	.093V	+18.5	< 100mv
100	250	+18.5V	2K	9.3ma	.93V	+18.5	< 100mv
1000	2000	+2.3V	2K	1.2ma	1.2V	+2.3	< 100mv
10K	32K	+18.5V	256K	72μa	.72V	+18.5	< 100mv
100K	256K	+2.3V	256K	9μa	.9V	+2.3	< 100mv
1M	4.091M	+18.5V	4.091M	4.5μa	4.5V	+18.5	NA
10M	32.728M	+2.3V	4.091M	.56μa	5.6V	+2.3	NA
100M	261.824M	+2.3V/8	4.091M	70na	7V	+2.3	NA

* Approximate values (± 5%)

TP1 is always −7.0V
TP3 Ref common (use for low side of measurements)
TP4 amplifier offset (<10μv properly adjusted)
V_0 is proportional to RX
V_2 will vary some with range change

SCANNER: Voltages will appear on RT1 in order. $V_0 - V_1 - V_2$

Table 602-7. Range Switch Closures

0 = Switch Open

1 = Switch Closed

Chart applies for time the particular voltage is SCANNED. All other times "0" applies.

	K1	K2	K3	Q5	Q19	Q20	V_0 Q29	V_{2a} Q31	V_{2b} Q33	V_1 Q35
10Ω	1	0	1	0	0	1	1	1	0	1
100Ω	1	0	1	0	0	1	1	1	0	1
1KΩ	1	0	1	1	0	1	1	1	0	1
10KΩ	1	1	0	0	0	1	1	0	1	1
100KΩ	1	1	0	1	0	1	1	0	1	1
1MΩ	1	0	0	0	0	1	1	0	0	1
10MΩ	1	0	0	1	0	1	1	0	0	1
100MΩ	1	0	0	1	1	0	1	0	0	1
OHMS	0	0	0	1	0	1	0	0	0	0

Table 602-8. Address and Data Coding

ADDRESS IC1, 2, 3 HIGH									
Range	V	IDϕ	ID1	ID2	ID3	ID4	ID5	ID6	ID7
10	V_ϕ	0	1	1	0	0	1	1	0
	V_1	1	0	1	0	0	1	1	0
	V_2	1	1	0	0	0	1	1	0
100	V_ϕ	0	1	1	0	0	1	1	0
	V_1	1	0	1	0	0	1	1	0
	V_2	1	1	0	0	0	1	1	0
1K	V_ϕ	0	1	1	0	1	1	1	0
	V_1	1	0	1	0	1	1	1	0
	V_2	1	1	0	0	1	1	1	0
10K	V_ϕ	0	1	1	0	0	0	1	1
	V_1	1	0	1	0	0	0	1	1
	V_2	1	1	0	0	0	0	1	1
100K	V_ϕ	0	1	1	0	1	0	1	1
	V_1	1	0	1	0	1	0	1	1
	V_2	1	1	0	0	1	0	1	1
1M	V_ϕ	0	1	1	0	0	1	1	1
	V_1	1	0	1	0	0	1	1	1
10M	V_ϕ	0	1	1	0	1	1	1	1
	V_1	1	0	1	0	1	1	1	1
100M	V_ϕ	0	1	1	0	1	1	0	1
	V_1	1	0	1	0	1	1	0	1
OHMS		1	1	1	1	1	1	1	1

Table 602-9. Ohms Converter PCB Assembly

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
-02	®OHMS CONVERTER PCB ASSEMBLY FIGURE 602-4 (MIS-4110T)	ORDER	BY	OPTION -02			
C1	CAP, TA, 6.8 UF +/-20%, 35V	363713	56289	196D685X0035KA1	4		
C2	CAP, TA, 6.8 UF +/-20%, 35V	363713	56289	196D685X0035KA1	REF		
C3	CAP, TA, 6.8 UF +/-20%, 35V	363713	56289	196D685X0035KA1	REF		
C4	CAP, TA, 6.8 UF +/-20%, 35V	363713	56289	196D685X0035KA1	REF		
C5	CAP, CER, 33 PF +/-2%, 100V	354852	80031	2222-638-10339	1		
C6	CAP, CER, 1200 PF +/-20%, 100V	358283	80031	2222-630-01-122	2		
C7	CAP, CER, 1200 PF +/-20%, 100V	358283	80031	2222-630-01-122	REF		
C8	CAP, POLYSTRYRN, 100 PF +/-10%, 500V	446609	89536	446609	1		
C9	CAP, CER, 0.01 UF +/-20%, 100V	149153	56289	C023B101F103M	7		
C10	CAP, CER, 0.01 UF +/-20%, 100V	149153	56289	C023B101F103M	REF		
C11	CAP, TA, 22 UF +/-20%, 15V	423012	56289	196D226X0015KA1	1		
C12	CAP, CER, 0.01 UF +/-20%, 100V	149153	56289	C023B101F103M	REF		
C13	CAP, CER, 0.01 UF +/-20%, 100V	149153	56289	C023B101F103M	REF		
C14	CAP, CER, 0.01 UF +/-20%, 100V	149153	56289	C023B101F103M	REF		
C15	CAP, CER, 0.01 UF +/-20%, 100V	149153	56289	C023B101F103M	REF		
C16	CAP, TA, 5.6 UF +/-20%, 25V	368869	56289	196D565X0025KA1	1		
C17	CAP, CER, 0.22 UF +/-20%, 50V	309849	71590	CW30C224K	3		
C18	CAP, TA, 0.47 UF +/-20%, 35V	161349	56289	196D474X0035HA1	1		
C19	CAP, CER, 0.01 UF +/-20%, 100V	149153	56289	C023B101F103M	REF		
C20	CAP, CER, 0.0022 UF +/-10%, 500V	268425	32897	851000Z5R222K	1		
C21	CAP, CER, 0.22 UF +/-20%, 50V	309849	71590	CW30C224K	REF		
C22	CAP, TA, 0.33 UF +/-20%, 35V	408690	56289	196D334X0035HA1	1		
C23	CAP, CER, 0.22 UF +/-20%, 50V	309849	71590	CW30C224K	REF		
CR1	DIODE, SI, HI-SPEED SWITCHING	203323	07910	1N4448	6	2	
CR2	DIODE, SI, HI-SPEED SWITCHING	203323	07910	1N4448	REF		
CR3	DIODE, SI, HI-SPEED SWITCHING	203323	07910	1N4448	REF		
CR4	DIODE, SI, RECT	428144	01295	1N4006	7	2	
CR7	DIODE, SI, RECT	428144	01295	1N4006	REF		
CR8	DIODE, SI, RECT	428144	01295	1N4006	REF		
CR9	DIODE, ZENER, UNCOMP	113324	07910	1N961A	2	1	
CR10	DIODE, SI, MULTIPELLET	375485	09214	MPD300	2	1	
CR11	DIODE, SI, HI-SPEED SWITCHING	203323	07910	1N4448	REF		
CR12	DIODE, SI, MULTIPELLET	375485	09214	MPD300	REF		
CR13	DIODE, SI, RECT	428144	01295	1N4006	REF		
CR14	DIODE, SI, RECT	428144	01295	1N4006	REF		
CR15	DIODE, SI, RECT	428144	01295	1N4006	REF		
CR16	DIODE, SI, HI-SPEED SWITCHING	203323	07910	1N4448	REF		
CR17	DIODE, SI, RECT	428144	01295	1N4006	REF		
CR18	DIODE, ZENER, UNCOMP	113324	07910	1N961A	REF		
CR19	DIODE, 2-PELLET	375477	09214	MPD200	1	1	
CR20	DIODE, SI, HI-SPEED SWITCHING	203323	07910	1N4448	REF		
E1	SURGE PROTECTOR, VOL	442723	25088	B1-C145	1		
H1	SCREW, PHP, 4-40 X 5/8	413062	89536	413062	1		
K1	RELAY, ARMATURE	515429	89536	515429	1		
K2	RELAY, DRY REED	357582	71707	UF40070	2		
K3	RELAY, DRY REED	357582	71707	UF40070	REF		
L1	CHOKE, RF	111542	99800	1537-76	1		

Table 602-9. Ohms Converter PCB Assembly (cont)

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
MP1	CASE ASSY (INCLUDES MP2-MP9)	458927	89536	458927	1		1
MP2	CASE HALF, MODULE	402990	89536	402990	REF		
MP3	CASE HALF, MODULE	402990	89536	402990	REF		
MP4	COVER, MODULE CASE	402974	89536	402974	REF		
MP5	SHIELD, COVER	411942	89536	411942	REF		
MP6	DECAL, OHMS CONVERTER	413435	89536	413435	REF		
MP7	DECAL, CAUTION	454504	89536	454504	REF		
MP8	GUARD, REAR	383364	89536	383364	REF		
MP9	GUARD, FRONT	383356	89536	383356	REF		
MP11	SPACER, XSTR	152207	07047	10123-DAP	5		
MP12	SOCKET, COMPONENT LEAD (NOT SHOWN) (W/R20,R21,R23,R26)	343285	00779	2-331272-6	8		
MP13	LUG, SOLDER	103531	77963	501	1		
MP14	SPRING, COIL (NOT SHOWN)	424465	83553	C0120-014-0380	1		
Q1	XSTR, SI, NPN	226290	04713	MPS3640	1	1	
Q2	XSTR, SI, NPN	218396	04713	2N3904	14	3	
Q3	XSTR, SI, PNP	195974	04713	2N3906	7	2	
Q4	XSTR, SI, NPN	218396	04713	2N3904	REF		
Q5	XSTR, FET, N-CHANNEL	261578	89536	261578	4	1	
Q6	XSTR, SI, PNP	168716	07263	S19254	3	1	
Q7	XSTR, SI, PNP	168716	07263	S19254	REF		
Q8	XSTR, SI, NPN	218396	04713	2N3904	REF		
Q9	XSTR, FET, DUAL, N-CHANNEL	476309	89536	476309	1	1	
Q10	XSTR, SI, NPN	203489	09214	11C2322	5	1	
Q11	XSTR, SI, NPN	203489	09214	11C2322	REF		
Q12	XSTR, SI, PNP	195974	04713	2N3906	REF		
Q13	XSTR, SI, NPN	218396	04713	2N3904	REF		
Q14	XSTR, SI, NPN	203489	09214	11C2322	REF		
Q15	XSTR, SI, NPN	203489	09214	11C2322	REF		
Q16	XSTR, SI, NPN	203489	09214	11C2322	REF		
Q17	XSTR, SI, PNP	195974	04713	2N3906	REF		
Q18	XSTR, SI, NPN	218396	04713	2N3904	REF		
Q19	XSTR, FET, N-CHANNEL	261578	89536	261578	REF		
Q20	XSTR, FET, N-CHANNEL	261578	89536	261578	REF		
Q21	XSTR, SI, PNP	195974	04713	2N3906	REF		
Q22	XSTR, SI, NPN	218396	04713	2N3904	REF		
Q23	XSTR, SI, NPN	218396	04713	2N3904	REF		
Q24	XSTR, SI, PNP	195974	04713	2N3906	REF		
Q25	XSTR, SI, NPN	218396	04713	2N3904	REF		
Q26	XSTR, SI, PNP	195974	04713	2N3906	REF		
Q27	XSTR, SI, NPN	218396	04713	2N3904	REF		
Q28	XSTR, SI, NPN	218396	04713	2N3904	REF		
Q29	XSTR, FET, N-CHANNEL	393314	89536	393314	4	1	
Q30	XSTR, SI, NPN	218396	04713	2N3904	REF		
Q31	XSTR, FET, N-CHANNEL	393314	89536	393314	REF		
Q32	XSTR, SI, NPN	218396	04713	2N3904	REF		
Q33	XSTR, FET, N-CHANNEL	393314	89536	393314	REF		
Q34	XSTR, SI, NPN	218396	04713	2N3904	REF		
Q35	XSTR, FET, N-CHANNEL	393314	89536	393314	REF		
Q36	XSTR, FET, N-CHANNEL	261578	89536	261578	REF		

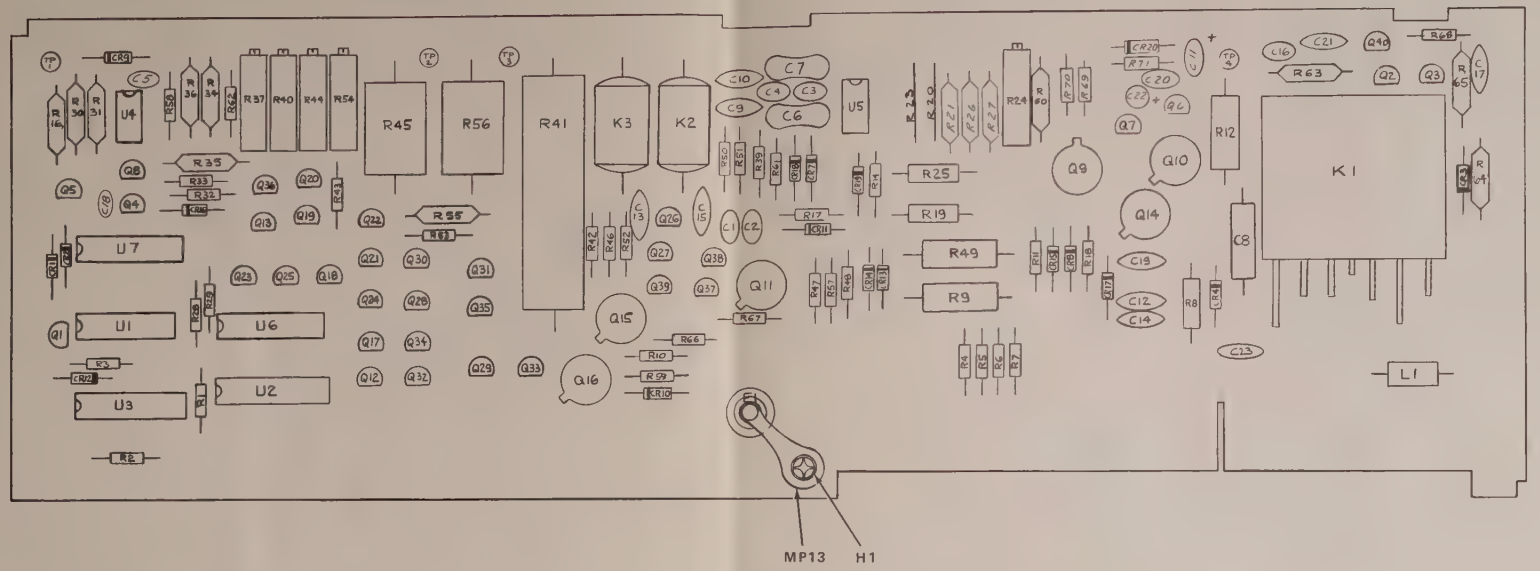
Table 602-9. Ohms Converter PCB Assembly (cont)

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
Q38	XSTR, SI, PNP	195974	04713	2N3906	REF		
Q39	XSTR, SI, PNP	168716	07263	S19254	REF		
Q40	XSTR, FET JUNCTION, N-CHANNEL	288324	89536	288324	1	1	
R1	RES, DEP. CAR, 20K +/-5%, 1/4W	441477	80031	CR251-4-5P20K	7		
R2	RES, DEP. CAR, 150 +/-5%, 1/4W	343442	80031	CR251-4-5P150E	6		
R3	RES, DEP. CAR, 20K +/-5%, 1/4W	441477	80031	CR251-4-5P20K	REF		
R4	RES, DEP. CAR, 150 +/-5%, 1/4W	343442	80031	CR251-4-5P150E	REF		
R5	RES, DEP. CAR, 150 +/-5%, 1/4W	343442	80031	CR251-4-5P150E	REF		
R6	RES, DEP. CAR, 150 +/-5%, 1/4W	343442	80031	CR251-4-5P150E	REF		
R7	RES, DEP. CAR, 150 +/-5%, 1/4W	343442	80031	CR251-4-5P150E	REF		
R8	RES, COMP, 220K +/-5%, 1/2W	109025	01121	EB2245	1		
R9	RES, COMP, 1.8K +/-5%, 1W	180331	01121	GB1825	2		
R10	RES, DEP. CAR, 20K +/-5%, 1/4W	441477	80031	CR251-4-5P20K	REF		
R11	RES, DEP. CAR, 20K +/-5%, 1/4W	441477	80031	CR251-4-5P20K	REF		
R12	RES, COMP, 100K +/-5%, 1W	109397	01121	GB1041	1		
R14	RES, DEP. CAR, 20K +/-5%, 1/4W	441477	80031	CR251-4-5P20K	REF		
R16	RES, MTL. FILM, 30.1K +/-1%, 1/8W	293431	91637	MFF1-83012F	1		
R17	RES, DEP. CAR, 1M +/-5%, 1/4W	348987	80031	CR251-4-5P1M	6		
R18	RES, DEP. CAR, 1M +/-5%, 1/4W	348987	80031	CR251-4-5P1M	REF		
R19	RES, WW, 40K +/-0.1%	271403	89536	271403	2		
R20	RES, SELECTED				1		
R21	RES, MTL. FILM, 10 +/-1%, 1/8W	268789	91637	MFF1-8A100F	2		
R23	RES, SELECTED				REF		
R24	RES, VAR, CERMET, 100 +/-20%, 1/2W	267823	11236	190PC101B	1		
R25	RES, WW, 40K +/-0.1%	271403	89536	271403	REF		
R26	RES, MTL. FILM, 10 +/-1%, 1/8W	268789	91637	MFF1-8A100F	REF		
R27	RES, MTL. FILM, 20K +/-1%, 1/8W	291872	91637	MFF1-82002F	1		
R28	RES, DEP. CAR, 39K +/-5%, 1/4W	442400	80031	CR251-4-5P39K	2		
R29	RES, DEP. CAR, 39K +/-5%, 1/4W	442400	80031	CR251-4-5P39K	REF		
R30	RES, MTL. FILM, 11.3K +/-1%, 1/8W	335414	91637	MFF1-81132F	1		
R31	RES, MTL. FILM, 80.6K +/-1%, 1/8W	312710	91637	MFF1-88062F	1		
R32	RES, DEP. CAR, 1M +/-5%, 1/4W	348987	80031	CR251-4-5P1M	REF		
R33	RES, DEP. CAR, 180K +/-5%, 1/4W	348946	80031	CR251-4-5P180K	1		
R34	RES, MTL. FILM, 3.16K +/-0.1%, 1/8W	340588	91637	MFF1-83161B	1		
R35	RES, MTL. FILM, 21.5K +/-0.1%, 1/8W	344440	91637	MFF1-82152B	1		
R36	RES, MTL. FILM, 100K +/-1%, 1/8W	248807	91637	MFF1-81003F	1		
R37	RES, VAR, CERMET, 50K +/-10%, 1/2W	330688	11236	190PC503B	1		
R39	RES, DEP. CAR, 1.6K +/-5%, 1/4W	348805	80031	CR251-4-5P1K6	1		
R40	RES, VAR, CERMET, 10K +/-10%, 1/2W	267880	11236	190PC103B	1		
R41	RES, WW, 4.091M +/-0.1%, 2W	412205	89536	412205	1		
R42	RES, DEP. CAR, 20K +/-5%, 1/4W	441477	80031	CR251-4-5P20K	REF		
R43	RES, DEP. CAR, 1M +/-5%, 1/4W	348987	80031	CR251-4-5P1M	REF		
R44	RES, VAR, CERMET, 500 +/-20%, 1/2W	267849	11236	190PC501B	1		
R45	RES, WW, 272.84K +/-0.08%, 1/2W	412197	89536	412197	1		
R46	RES, DEP. CAR, 3.3K +/-5%, 1/4W	348813	80031	CR251-4-5P3K3	1		
R47	RES, DEP. CAR, 120K +/-5%, 1/4W	441386	80031	CR251-4-5P120K	4		
R48	RES, DEP. CAR, 470 +/-5%, 1/4W	343434	80031	CR251-4-5P470E	2		
R49	RES, COMP, 1.8K +/-5%, 1W	180331	01121	GB1825	REF		
R50	RES, DEP. CAR, 2.7K +/-5%, 1/4W	386490	80031	CR251-4-5P2K7	2		
R51	RES, DEP. CAR, 2.7K +/-5%, 1/4W	386490	80031	CR251-4-5P2K7	REF		

Table 602-9. Ohms Converter PCB Assembly (cont)

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
R52	RES, DEP. CAR, 150 +/-5%, 1/4W	343442	80031	CR251-4-5P150E	REF		
R53	RES, DEP. CAR, 1M +/-5%, 1/4W	348987	80031	CR251-4-5P1M	REF		
R54	RES, VAR, CERMET, 200K +/-20%, 1/2W	381509	11236	190PC204B	1		
R55	RES, MTL. FILM, 332K +/-1%, 1/8W	289504	91637	MFF1-83323F	1		
R56	RES, WW, 2.01K +/-0.1%, 1/2W	412189	89536	412189	1		
R57	RES, DEP. CAR, 1M +/-5%, 1/4W	348987	80031	CR251-4-5P1M	REF		
R58	RES, DEP. CAR, 1K +/-5%, 1/4W	343426	80031	CR251-4-5P1K	2		
R59	RES, DEP. CAR, 20K +/-5%, 1/4W	441477	80031	CR251-4-5P20K	REF		
R60	RES, MTL. FILM, 1M +/-1%, 1/8W	268797	91637	MFF1-81004F	1		
R61	RES, DEP. CAR, 120K +/-5%, 1/4W	441386	80031	CR251-4-5P120K	REF		
R62	RES, DEP. CAR, 120K +/-5%, 1/4W	441386	80031	CR251-4-5P120K	REF		
R63	RES, MTL. FILM, 15.8K +/-1%, 1/8W	293688	91637	MFF1-81582F	1		
R64	RES, MTL. FILM, 73.2K +/-1%, 1/8W	237222	91637	MFF1-87322D	1		
R65	RES, MTL. FILM, 30.1K +/-1%, 1/8W	168286	91637	MFF1-83012F	1		
R66	RES, DEP. CAR, 120K +/-5%, 1/4W	441386	80031	CR251-4-5P120K	REF		
R67	RES, DEP. CAR, 1K +/-5%, 1/4W	343426	80031	CR251-4-5P1K	REF		
R68	RES, DEP. CAR, 560K +/-5%, 1/4W	342642	80031	CR251-4-5P560K	1		
R69	RES, DEP. CAR, 300 +/-5%, 1/4W	441519	80031	CR251-4-5P300E	1		
R70	RES, DEP. CAR, 200K +/-5%, 1/4W	441485	80031	CR251-4-5P200K	1		
R71	RES, DEP. CAR, 470 +/-5%, 1/4W	343434	80031	CR251-4-5P470E	REF		
U1	⊗IC, C-MOS, NAND GATES	375147	02735	CD4023AE	1	1	
U2	⊗IC, C-MOS, QUAD, CLOCKED "D" LATCH	355149	02735	CD4042AE	2	1	
U3	⊗IC, C-MOS, QUAD, CLOCKED "D" LATCH	355149	02735	CD4042AE	REF		
U4	IC, LIN, OPNL AMPL	363515	34333	SG301A	1	1	
U5	IC, LIN, OPNL AMPL	418566	12040	LM358N	1	1	
U6	IC, RES NETWORK	380618	89536	380618	2	1	
U7	IC, RES NETWORK	380618	89536	380618	REF		

1 SEE TABLE 5-17 AT THE END OF SECTION 5.



MIS-1710

Figure 602-4. Ohms Converter PCB Assembly

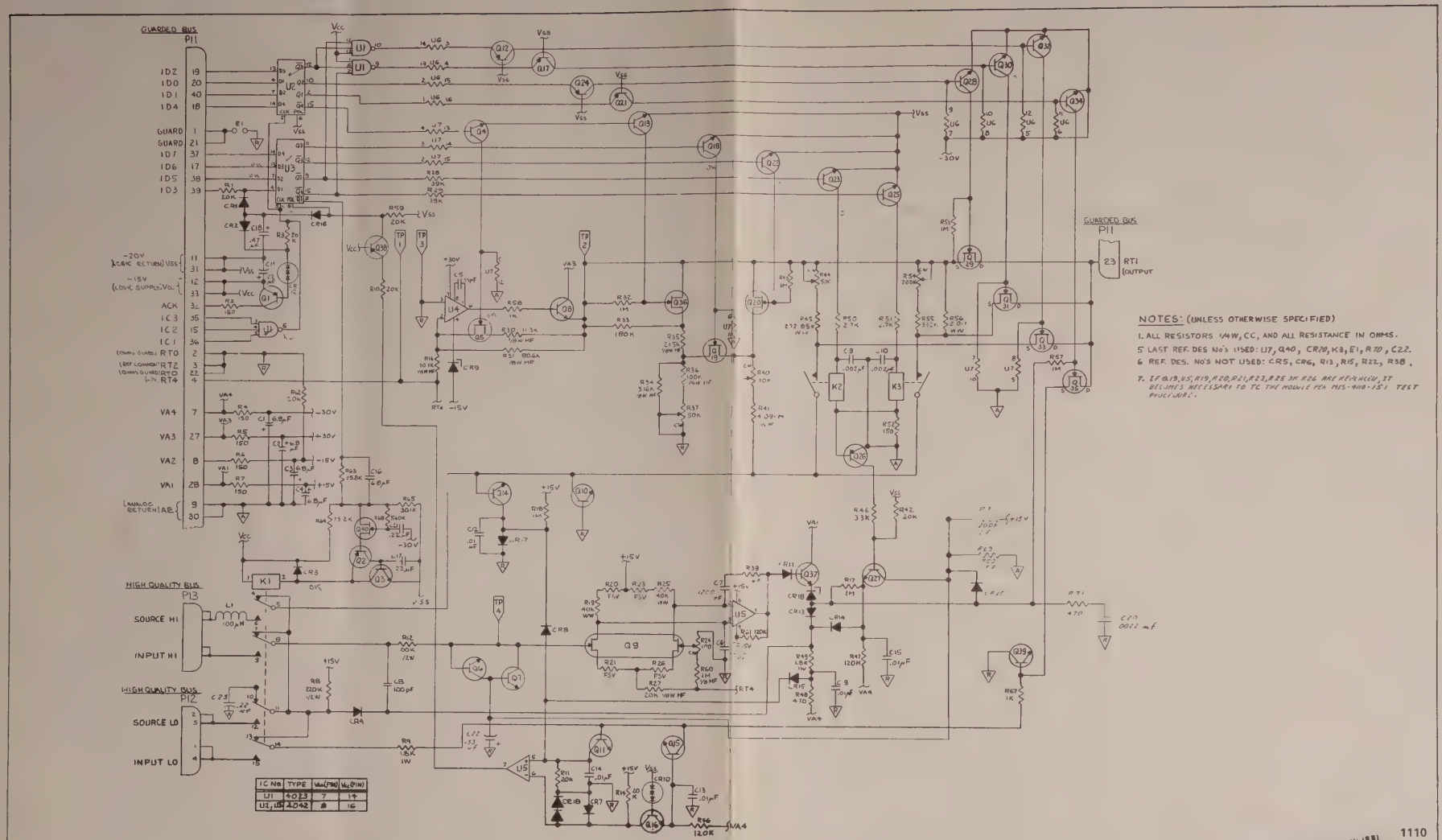

GUARDED BUS P11
HIGH QUALITY BUS P13
HIGH QUALITY BUS P12
SOURCE HI
INPUT HI
SOURCE LO
INPUT LO
GUARD
ACK
RTO
RT2
RT4
VA4
VA3
VA2
VA1
AB
RT1 (OUTPUT
NOTES: (UNLESS OTHERWISE SPECIFIED)
1. ALL RESISTORS 1/4W, CC, AND ALL RESISTANCE IN OHMS.
5 LAST REF. DES NO'S USED: U7, Q40, CR20, K3, E1, R70, C22.
6 REF. DES. NO'S NOT USED: CR5, CR6, R13, R15, R22, R38.
7. IF Q19, U5, R19, R20, R21, R23, R25 3K R26 ARE REPLACED, IT BECOMES NECESSARY TO TC THE MODULE PER MIS-4110-151 TEST PROCEDURE.
IC No | TYPE | VCC(PIN) | VEE(PIN)
U1 | 4023 | 7 | 14
U2, U3 | 2042 | 8 | 16

Figure 602-4. Ohms Converter PCB Assembly (cont)

345803	——	RES. CF., ¼W, 1.6K	R39
180331	——	RES. C.C., 1W, 1.8K	R9
343442	——	RES. CF., ¼W, 150 Ω	R2, 4-5
330689	——	RES, VAR, 50K	R37
330688	——	RES, VAR, 50K	R54
267860	——	RES, VAR, 10K	R40
267849	——	RES. VAR, 500 Ω	R44
267823	——	RES. VAR. 100 Ω	R24
772285	——	RELAY, DRY REED	K2,3
412205	——	RES, W.W, 4.091 M	RA1
790634	——	RES, W.W. 2.021K	R56
412197	——	RES. W.W, 272.85K	R45
110726		DIODE. ZENER, 13 V, 5%	CR22
428144	——	DIODE. IN4006	110
261578	——	XSTR, UZ366E	Q5,17 20,26
226290	——	XSTR. P.N.P., UPS360	Q1
165715	——	XSTR, N.P.N. CDQ2315B	Q6,7 19
215396	——	XSTR. N.P.N., 2N3904	108
195974	——	XSTR P.N.P., 2N3906	109
113324	——	DIODE. ZENER, IN961A	CR9, 12
715078		RELAY. DS4E. LATCHING	K1
360618	——	RES. NETWORK. 100K	Z6,7
203323	——	DIODE, IN4448	107
393314	——	XSTR. FET. 30721	Q29,31 32,33
363515	——	I.C., AN3015AN	U4
203489	——	XSTR, N.P.N., I.C 2822	Q10,11 14,15
375477	——	DIODE MULTI-PELLET	CR19
355149	——	I.C., 4042	U2,3
375147	——	I.C., 4023	U1

715052		MOV. 8V	RV1
442913	——	STANDOFF	—
179283	——	TERMINAL	TP1-4
524140		XSTR. PNP, MPS-A63	Q41
476309	——	DUAL FET, DN1139	Q9
441519	——	RES, CF, ¼W, 300 Ω	R69
441485	——	RES, CF, ¼W, 200 K	R70
453530	——	BAG, ANTISTATIC 8×12	—
103531	——	LUG	—
413062	——	SCREW, #4-40 × ⅞	—
424465	——	COIL SPRING	—
161943		CAP, TANT, 4.7 uf	C17 C21
405690	——	CAP, TANT, .33 uf	C22
446609	——	CAP, 100 pf	C8
348513	——	RES, CF, ¼W, 3.3K	114
369181		CAP. ELECTROLYTIC, 220 uf	C24
268425	——	CAP. CERAMIC, .0022 uf	C20
161349	——	CAP. TANT, .47 uf	C18
309549	——	CAP, CERAMIC, .22 uf	C23
573345		RES CF. 1/4W, @ 2K	R73
268797	——	RES, MF ⅛W, 1N	R60
573170	——	RES, CF, ¼W, 1K	118
109025	——	RES, CC, ½W, 220K	R8
575485	——	DIODE, MPD 300	CR10,13

293686	——	RES, MF., ⅛W, 15.8 K	RG3
418566	——	IC.-LM358N	U5
343285	——	SOCKET	6
115469	——	-22 BUSS WIRE	R2,23
268789	——	RES, M.F. ⅛W, 10 Ω	R21,22
109397	——	RES, C.C., 1W, 100K	R12
812223	——	CAP, CERAMIC, 1200 pf	C6,7
442723	——	SURG PROTECTOR	E1
149153	——	CAP, CERAMIC, .01 uf	C9,10 12-15,19
423012	——	CAP, TANT, 22 uf	C11
715250		CAP, ELECTROLYTIC, 33 uf	C25
706424	——	RES, M.F., ⅛W, 174 K	R55
248507	——	RES, M.F. ⅛W, 100K	R36
340588	——	RES, M.F., ⅛W, 3.16K	R34
354552	——	CAP, CERAMIC, 33 pf	C5
363713	——	CAP, TANT, 6.8 uf	C14
386490	——	RES, C.F., ¼W, 2.7K	R50,51
344440	——	RES, M.F., ⅛W, 21.5K	R35
271403	——	RES, W.W., 40K	R19,25
441477	——	RES, C. ¼W. 20K	112
174755		CHOKE, 1537-76100 uH	L1
293431	——	RES, MF. ½W, 30J K	R16
312710	——	RES, M.F., ⅛W, 80.6K	R31
335414	——	RES, MF., ⅛W, 11.3K	R30
291872	——	RES, M.F. ⅛W, 20K	R27
348946	——	RES, CF., ¼W. 100K	R33
343434	——	RES, CF, ¼W, 470 Ω	R43,44
442400	——	RES. CF. ¼W, 39 K	R23,28
441386	——	RES CF, ⅛W, 20K	R47,48 52,53
348987	——	RES, C ¼W, 1N	111

107 CR1.2.3.11.16.20.21.23.24.

106 Q2,Q12,Q17,Q21,Q24,Q26,Q38

109 Q3,Q4,Q5,Q13,Q16,Q22,Q23,Q25,Q27,Q28,Q30, Q32,Q34,Q37

110 CR4,CR7,CR8,CR13,CR14,CR15,CR17

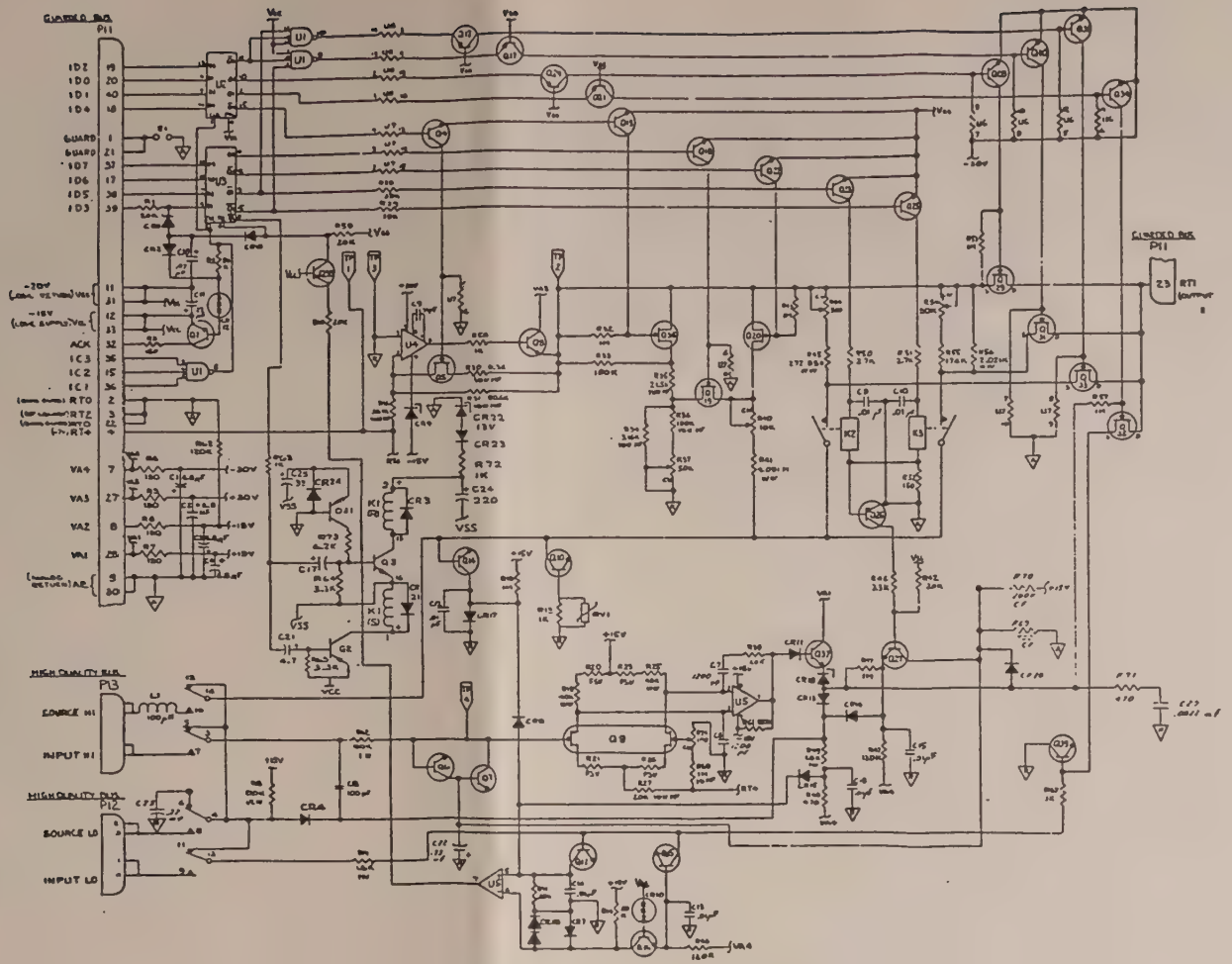
111 R17,R18,R32,R43,R53,R57

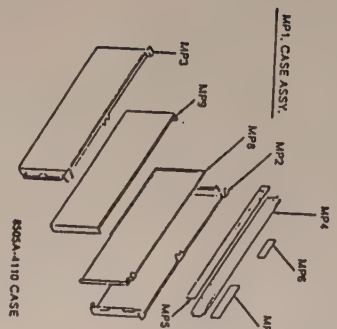
112 R1,R3,R10,R11,R14,R41,R59

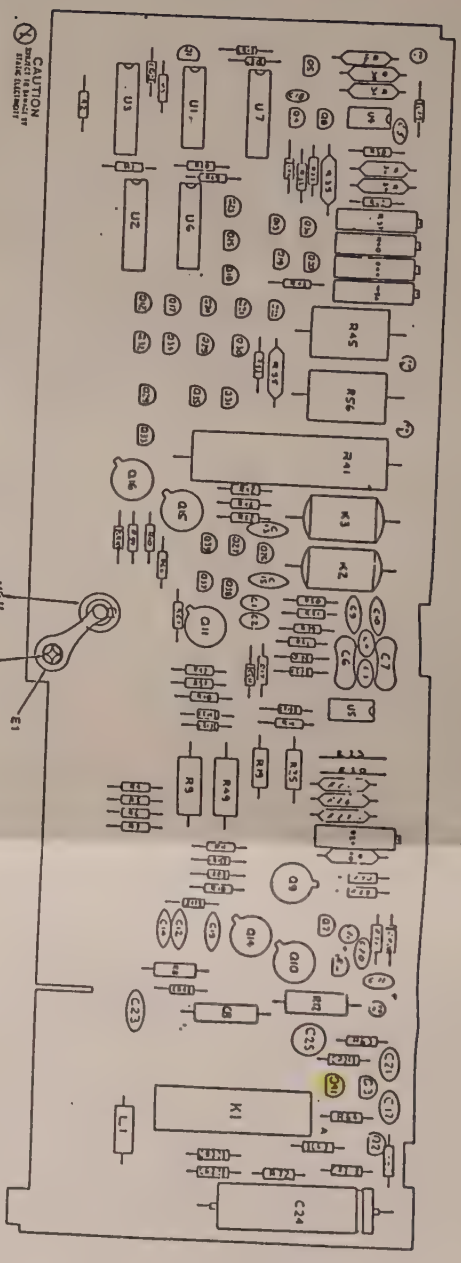
R58,63,67,72,R13

114 R40,64,65.

Schematic, P/L for S/N Above Rev F in above 3770000 S/N







ORIENTATION OF Q41 IS SHOWN IN REVERSE ORDER PER ECO 30108

LATE VERSION OHMS CONVERTER

NOTES:

1. FOR SCHEMATIC DIAGRAM SEE MIS - 1110.
2. FOR PCB DETAIL DWG. SEE MIS-3110.
3. FOR ASSEMBLY DWG. SEE MIS-4110.

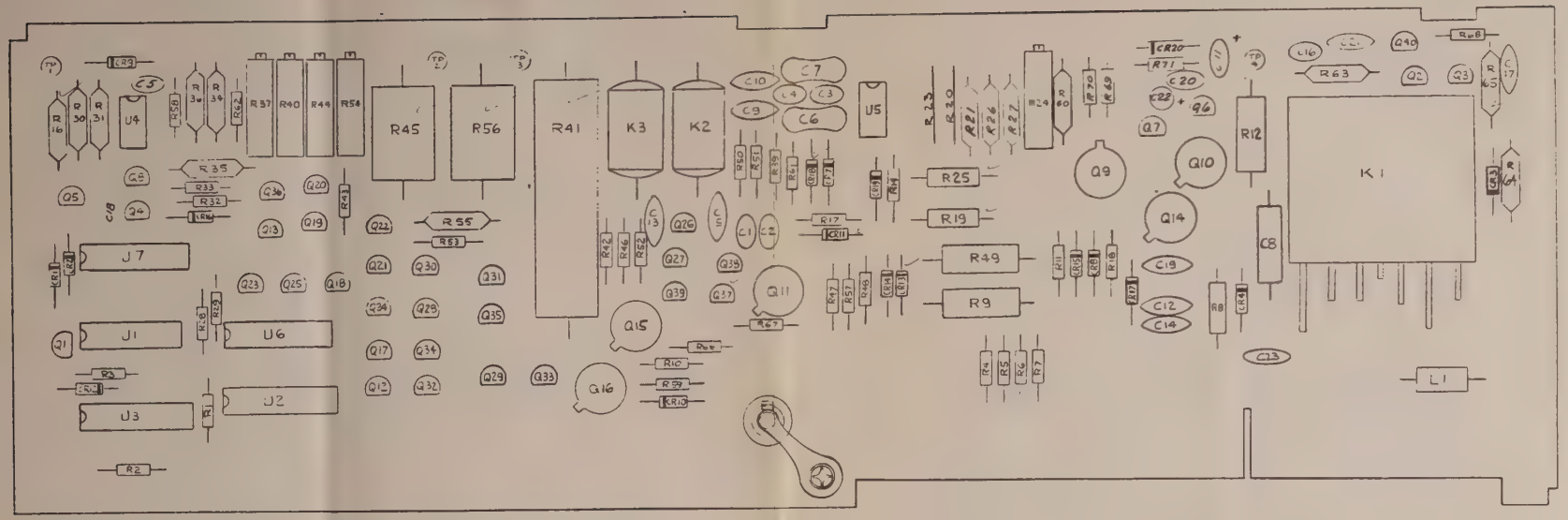
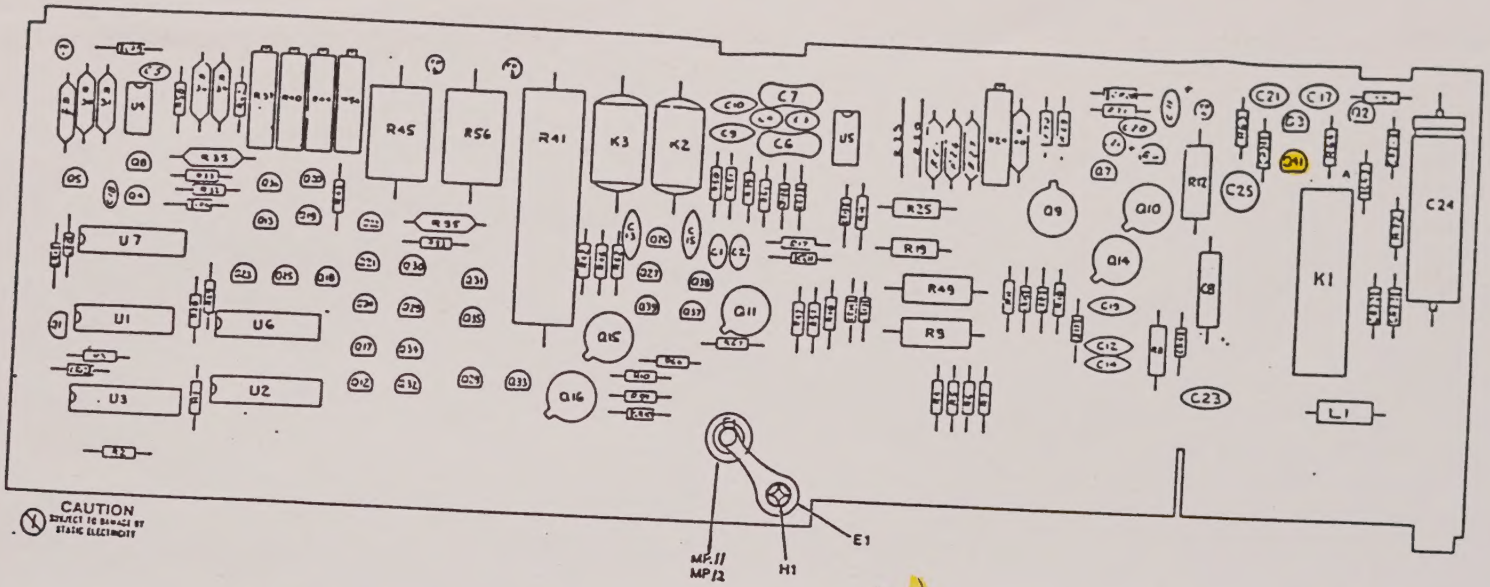
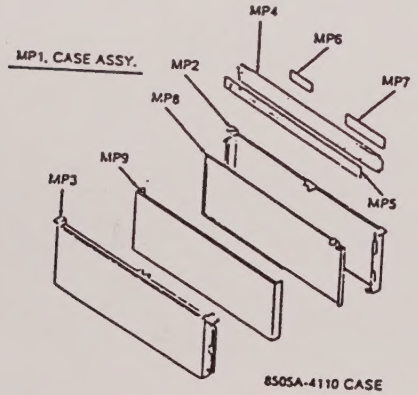


Figure 602-4. Ohms Converter, Assembly (M.I.S.-1710)



LATE VERSION
OHMS CONVERTER



ORIENTATION OF Q41 IS SHOWN IN REVERSE ORDER PER DCO 30108

MODULE/PCB REPLACEMENT
(SERVICE LEVEL - TESTED)
716308